CLAIMS

1. A control system (12) for a medical system having at least one pump (16, 60a, 60b, 66, 150) for pumping fluid, the control system comprising a sensor (27, 54a, 54b, 78) for measuring the flow rate of fluid in a medical system generated by at least one pump (16, 60a, 60b, 66, 150), the flow rate sensor (27, 54a, 54b, 78) providing flow rate data signals correlated to the fluid flow rate, and a controller (160) operably connectable to the at least one pump (16, 60a, 60b, 66, 150) in a medical system and operably connected to the flow rate sensor (27, 54a, 54b, 78), the controller (160) receiving the flow rate data signals and the controller providing an output signal for the at least one pump (16, 60a, 60b, 66, 150) to adjust, as necessary on a periodic ongoing basis, the flow rate of fluid generated by the at least one pump, characterised in that the control system further comprises at least one monitor (100, 110, 120, 130, 140) for measuring at least one predetermined patient parameter; said least one patient parameter monitor (100, 110, 120, 130, 140) providing patient parameter data signals correlated to said at least one patient parameter, in that the controller is a supervisory controller (160) which is also operably connected to said at least one patient parameter monitor (100, 110, 120, 130, 140); in that the controller (160) also receives the patient parameter data signals, and in that the controller analyses the received signals utilising fuzzy logic based on at least one predetermined supervisory rule, and then provides the output signal.

2. The control system of claim 1, wherein said at least one patient parameter monitor is selected from the group consisting of a blood pressure monitor (130) providing blood pressure data signals, a heart rate monitor (120) providing heart rate data signals, and combinations thereof.

3. The control system of claim 2, wherein the medical system is an ultrafiltration system and the at least one predetermined supervisory rule is selected from the group consisting of

a) If heart rate is high and blood pressure is normal or low, then decrease ultrafiltration and wait a first predetermined time.

b) If blood pressure is low and heart rate is normal or high, then decrease ultrafiltration and wait a second predetermined time.

c) If blood pressure is low and heart rate is low, then provide the user a choice between a decrease or increase of the ultrafiltration rate and wait a third predetermined time.

d) If blood pressure is high and heart rate is high for a fourth predetermined time, then provide the user with a choice between a decrease or increase of the ultrafiltration rate.

e) If blood pressure is high and heart rate is low for a fifth predetermined time, then increase ultrafiltration.

f) The lowest possible value of ultrafiltration is a predetermined minimum rate per hour and the highest possible value of the ultrafiltration rate is a predetermined percentage above that of a predetermined maximum ultrafiltration rate.

g) If an increase in ultrafiltration occurs such that the filtered fraction is greater than a predetermined filtered fraction, increase the blood pump flow such that the filtered fraction equals the predetermined filtered fraction.

4. The control system of any preceding claim, further comprising a second sensor (27, 54a, 54b, 78) for measuring the flow rate of fluid in a medical system generated by a second pump (16, 60a, 60b, 66, 150), the second flow rate sensor providing second flow rate data signals correlated to the fluid flow rate, wherein the supervisory controller (160) is further operably connectable to the second pump (16, 60a, 60b, 66, 150) and operably connected to the second flow rate sensor (27, 54a, 54b, 78), the controller receiving the second flow rate data signals and analysing the signals utilising fuzzy logic based on at least one predetermined supervisory rule and the controller then providing an output signal for the second pump (16, 60a, 60b, 66, 150) to adjust, as necessary on a periodic ongoing basis, the flow rate of fluid generated by the second pump.

5. The control system of claim 4, further comprising a third sensor (27, 54a, 54b, 78) for measuring the flow rate of fluid in a medical system generated by a third pump (16, 60a, 60b, 66, 150), the third flow rate sensor (27, 54a, 54b, 78) providing third flow rate data signals correlated to the fluid flow rate, wherein the supervisory controller (160) is further operably connectable to the third pump (16, 60a, 60b, 66, 150) and operably connected to the third flow rate sensor (27, 54a, 54b, 78), the controller receiving the third flow rate data signals and analysing the signals utilising fuzzy logic based on at least one predetermined supervisory rule and the controller then providing an output signal for the third pump (16, 60a, 60b, 66, 150) to adjust, as necessary on a periodic ongoing basis, the flow rate of fluid generated by the third pump.

6. The control system of claim 5, further comprising a fourth sensor (27, 54a, 54b, 78) for measuring the flow rate of fluid in a medical system generated by a fourth pump (16, 60a, 60b, 66, 150), the fourth flow rate sensor (27, 54a, 54b, 78) providing fourth flow rate data signals correlated to the fluid flow rate, wherein the supervisory controller is further operably

connectable to the fourth pump (16, 60a, 60b, 66, 150) and operably connected to the fourth flow rate sensor (27, 54a, 54b, 78), the controller receiving the fourth flow rate data signals and analysing the signals utilising fuzzy logic based on at least one predetermined supervisory rule and the controller then providing an output signal to the fourth pump (16, 60a, 60b, 66, 150) to adjust, as necessary on a periodic ongoing basis, the flow rate of fluid generated by the fourth pump.

7. The control system of any preceding claim, further comprising an adaptive controller (162, 170, 180a, 180b) operably connectable to the pump (16, 60a, 60b, 66, 150) and to said flow rate sensor (27, 54a, 54b, 78), the adaptive controller (162, 170, 180a, 180b) receiving said flow rate data signals, using an adaptive law to generate a set of controller parameters for correcting time-dependent deviations of the flow rate of the respective fluid from a predetermined blood flow rate, and using a control law to generate an output signal from the set of controller parameters for adjusting the pumping rate of fluid generated by the pump (16, 60a, 60b, 66, 150) to achieve the predetermined blood flow rate, said adaptive controller then providing the output signal for the pump (16, 60a, 60b, 66, 150) on a periodic ongoing basis.

8. A control system (12) for controlling the pumping rate of at least one pump (16, 60a, 60b, 66, 150) for pumping fluid in a medical system, said control system comprising a sensor (27, 54a, 54b, 78) for measuring the flow rate of liquid in a medical system generated by at least one pump (16, 60a, 60b, 66, 150), the flow rate sensor providing flow rate data signals correlated to the fluid flow rate, and a controller (162, 170, 180a, 180b) operably connectable to the at least one pump (16, 60a, 60b, 66, 150) in a medical system and operably connected to the flow rate sensor (27, 54a, 54b, 78), the controller (162, 170, 180a, 180b) receiving the flow rate data signals and generating an output signal for adjusting the pumping rate of fluid g nerated

by the at least one pump (16, 60a, 60b, 66, 150), the controller providing the output signal for the at least one pump on a periodic ongoing basis, characterised in that the controller is an adaptive controller (162, 170, 180a, 180b), the controller (162, 170, 180a, 180b) using an adaptive law to generate a set of controller parameters for correcting time-dependent deviations of the flow rate from a predetermined flow rate, and using a control law to generate the output signal from the set of controller parameters for adjusting the pumping rate of fluid generated by the at least one pump (16, 60a, 60b, 66, 150) to achieve the predetermined flow rate.

9. The control system of claim 8, wherein the adaptive law further includes parameter projections to limit the output signal to a range between a predetermined minimum output signal and a predetermined maximum output signal.

10. The control system of any preceding claim, wherein the sensor is selected from the group consisting of a flowmeter (27) and a weight scale (54a, 54b, 78).

11. The control system of claim 10, wherein the sensor is a weight scale (54a, 54b, 78) providing weight data signals and the flow rate data signals comprise the rate change in the weight data signals.

12. Continuous hemofiltration system for removal of fluid from the blood of a patient, comprising a hemofilter (24), a first pump (16) for pumping blood from a patient through the hemofilter (24) and back to the patient, a first reservoir (50) for maintaining a supply of infusate, a second pump (60) for pumping the infusate from the first reservoir (50) to the hemofilter (24), a second reservoir (74) for receiving drained fluid from the hemofilter (24), a third pump (66) for pumping the drained fluid from the hemofilter (24) to the second reservoir (74), and a control system as claimed in either claim 7 or claim 8 wherein the sensor to which the adaptive controller (162, 170, 180a,

180b) is operably connected is a flowmeter (27) downstream of the first pump (16) to measure the blood outflow from the first pump and wherein the adaptive controller (162, 170, 180a, 180b) is operably connected to the first pump (16) and generates an output signal for adjusting the pumping rate of fluid generated by the first pump (16).

13. The continuous hemofiltration system of claim 12 wherein the control system is as claimed in claim 7, wherein the sensor to which the supervisory controller is operably connected comprises a first scale (54) to measure the weight of infusate in the first reservoir (50), the first scale (54) generating infusate flow rate data signals correlated to the infusate weight and a second scale (78) to measure the weight of drained fluid in the second reservoir (74), the second scale (78) generating drained fluid flow rate data signals correlated to the drained fluid weight, and wherein the supervisory controller (160) is operably connected to the pumps (16, 60a, 60b, 66, 150) and to the flowmeter (27) and provides an output signal to the pumps (16, 60a, 60b, 66, 150).

14. Continuous filtration system for removal of fluid from the blood of a patient, comprising a hemofilter (24), a first pump (16) for pumping blood from a patient through the hemofilter and back to the patient, a second pump (60) for pumping the infusate from the first reservoir (50) to the hemofilter (24), a second reservoir (74) for receiving drained fluid from the hemofilter (24), a third pump (66) for pumping the drained fluid from the hemofilter (24) to the second reservoir (74) and a control system as claimed in any one of claims 1 to 7 wherein the sensor is a flowmeter (27) downstream of the first pump (16) to measure the blood outflow from the first pump, a first scale (54) to measure the weight of infusate in the first reservoir (50), the first scale (54) generating infusate flow rate data signals correlated to the infusate weight and a second scale (78) to measure the weight of drained fluid in the second reservoir (74), the second scale (78) generating drained fluid flow rate data signals

correlated to the drained fluid weight and wherein the supervisory controller (160) is operably connected to the pumps (16, 60a, 60b, 66, 150), and provides an output signal to one or more of the pumps (16, 60a, 60b, 66, 150) to adjust, as necessary on a periodic ongoing basis, the flow rate of fluid generated by the one or more of the pumps (16, 60a, 60b, 66, 150).

15. A method of controlling a pump pumping fluid in a medical system comprising measuring the flow rate of a fluid in a medical system generated by a pump (16, 60a, 60b, 66, 150) to obtain flow rate data signals correlated to the fluid flow rate and providing an output signal to the pump (16, 60a, 60b, 66, 150) to adjust, as necessary on a periodic ongoing basis, the flow rate of fluid generated by the pump, characterised in that the method further comprises measuring at least one patient parameter to obtain patient parameter data signals correlated to said at least one patient parameter, and analysing the flow rate data signals and the patient parameter data signals utilising fuzzy logic based on at least one predetermined supervisory rule, and then providing the output signal.

16. A method of controlling a pump pumping fluid in a medical system comprising measuring the flow rate of a fluid in a medical system generated by a pump (16, 60a, 60b, 66, 150) to obtain flow rate data signals correlated to the fluid flow rate generating an output signal for adjusting the pumping rate of fluid generated by the pump (16, 60a, 60b, 66, 150) to achieve a predetermined flow rate, and providing the output signal to the pump (16, 60a, 60b, 66, 150) on a periodic ongoing basis to correct the deviations of the flow rate from the predetermined flow rate, characterised in that the method further comprises generating a set of controller parameters from the flow rate signals for correcting time-dependent deviations of the flow rate from the predetermined flow rate and generating the output signal using a control law from the set of controller parameters.

17. Hemofiltration method for removal of fluid from the blood of a patient, comprising pumping blood from a patient through a hemofilter (24) and back to the patient, monitoring the blood outflow from the blood pump (16) and generating blood flow rate data signals, maintaining a supply of infusate in a first reservoir (50), monitoring the weight of infusate in the first reservoir (50) and generating infusate flow rate data signals, pumping the infusate to the hemofilter (24), pumping drained fluid from the hemofilter (24) into a second reservoir (74), monitoring the weight of drained fluid in the second reservoir (74) and generating drained fluid flow rate data signals, and controlling the pumping rate of the blood, the drained fluid, and the infusate with a programmed computer, the computer being responsive to the flow rate data signals, the computer receiving the rate data and generating an output signal to each pump (16, 60a, 60b, 66, 150) to adjust, as necessary on a periodic ongoing basis, the flow rate of fluid generated by each pump (16, 60a, 60b, 66, 150), characterised in that the method further comprises monitoring at least one predetermined patient parameter, such as patient heart rate and/or blood pressure, and generating parameter data signals correlated thereto, and in that the computer also receives the parameter data signals, utilises a supervisory controller (160) to analyse the received signals utilising fuzzy logic based on at least one predetermined supervisory rule, and then generates the output signal.

18. Hemofiltration method for removal of fluid from the blood of a patient, comprising pumping blood from a patient through a hemofilter (24) and back to the patient, monitoring the blood outflow from the blood pump (16) and generating blood flow rate data signals, maintaining a supply of infusate in a first reservoir (50), monitoring the weight of infusate in the first reservoir (50) and generating infusate flow rate date signals, pumping the infusate to the hemofilter (24), pumping drained fluid from the hemofilter (24) into a second reservoir (74), monitoring the weight of drained fluid in the second reservoir

(74) and generating drained fluid flow rate data signals, controlling the pumping rate of the blood, the drained fluid, and the infusate with a programmed computer to correspond to a set of predetermined pumping rates, the computer being responsive to the flow rate data signals and providing an output signal to at least one pump (16, 60a, 60b, 66, 150) on a periodic ongoing basis, characterised in that the method further comprises sensing the performance of the blood pump (16) and generating a first set of controller parameters from a first adaptive law, sending the performance of the infusate pump (60) and generating a second set of controller parameters from a second adaptive law and sensing the performance of the drained fluid pump (66) and generating a third set of controller parameters from a third adaptive law, and in that the computer also receives the controller parameters and uses a control law to generate the output signal from the flow rate data signals and the controller parameters for correcting time-dependent deviations of the flow rate from the set of predetermined pumping rates.